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(71) Applicant : FUJITSU LIMITED
1015, Kamikodanaka Nakahara-ku
Kawasaki-shi Kanagawa 211 (JP)

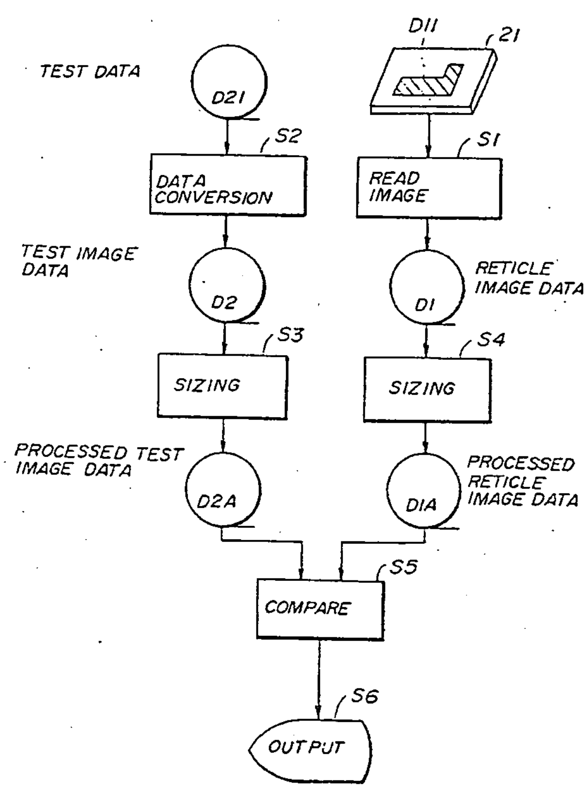
(72) Inventor : Matsui, Shogo, c/o FUJITSU LIMITED
1015, Kamikodanaka, Nakahara-ku
Kawasaki-shi, Kanagawa 211 (JP)
Inventor : Kobayashi, Kenichi, c/o FUJITSU LIMITED
1015, Kamikodanaka, Nakahara-ku
Kawasaki-shi, Kanagawa 211 (JP)

(74) Representative : Joly, Jean-Jacques et al
CABINET BEAU DE LOMENIE 55, rue d'Amsterdam
F-75008 Paris (FR)

(54) Image data inspecting method and apparatus.

(57) An image data inspecting method detects whether or not a pattern described by a first image data (D1) and a pattern described by a second image data (D2) match. This method includes the steps of (a) carrying out a sizing process on the first and second image data so that the patterns described thereby are at least enlarged or reduced by the same amount, and (b) comparing the first and second image data which are processed in the step (a) to determine whether or not the processed first and second image data (D1A, D2A) match.

FIG.3



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BACKGROUND OF THE INVENTION

The present invention generally relates to image data inspecting methods and apparatuses, and more particularly to an image data inspecting method for inspecting whether or not two image data related to a pattern of a solid state electronic device such as a semiconductor device match, and an image data inspecting apparatus which employs such an image data inspecting method.

When producing a solid state electronic device such as a semiconductor device, photomasks and reticles are made to form patterns of each layer of the electronic device. Even if an extremely small defect exists in the patterns of such photomasks and reticles, the defect would greatly affect the product production. For this reason, the patterns of the photomasks and reticles are inspected upon completion in order to check the accuracy of the patterns.

Generally, the patterns of the photomask or reticle are converted into an electrical signal, that is, an image data, when making the above described inspection. This image data is compared or collated with an image data which is made in advance at the designing stage. This comparison is made to determine whether or not the two image data match for all regions of the photomask or reticle, and it is necessary that the two image data match in their entirety when this inspection is made.

A description will be given of an example of a conventional reticle image inspecting method, by referring to FIG.1. In FIG.1, a pattern D11 which is formed on a reticle 61 by a metal thin film is converted into an electrical signal by an image reading part 62. The image reading part 62 is made up of an optical device which emits a reading light and a photoelectric conversion device which receives the reading light which is transmitted through the reticle pattern, for example. The image reading part 62 outputs a reticle image data D1 as the electrical signal.

For example, the entire region of the reticle is divided into units of the photoelectric conversion device, and the reticle image data D1 describes the pattern for each unit region. The signal format of the reticle image data D1 is such that the pattern is described by defining a center point coordinate (X1, Y1), a width (W1) and a height (H1) of the pattern.

A test data D21 is formed prior to the production of the reticle from a design mask data, similarly to the exposure data which is formed for the reticle production. The signal format of the test image data D21 is such that the pattern existing with the entire reticle is described by defining a center point coordinate (X2, Y2), a width (W2) and a height (H2) of the pattern. Accordingly, the signal formats of the test data D21 and the reticle image data D1 are different, and a format converting part 63 is provided to convert the signal format of the reticle image data D1. The format converting part 63 converts the test data D21 into a test image data D2.

A comparator part 66 compares the two image data D1 and D2, and outputs a detection signal which indicates whether or not the two image data D1 and D2 match. This detection signal is supplied to an output part 67. When the detection signal indicates that the two image data D1 and D2 match, this indicates that the inspected reticle is in satisfactory condition free of defects. On the other hand, when the detection signal indicates that the two image data D1 and D2 do not match, this indicates that the inspected reticle includes a defect. For the sake of convenience, the detection signal which indicates that the two image data D1 and D2 match will be referred to as a first detection signal, and the detection signal which indicates that the two image data D1 and D2 do not match will be referred to as a second detection signal.

The image data D1 and D2 may require correction if a modification or the like is made after the image data D1 and D2 are formed. In such a case, image data correcting parts 64 and 65 carry out corrections on the respective image data D1 and D2, such as correcting the rounded of the corner of the image.

The comparison of the two image data D1 and D2 corresponds to the process of continuously scanning to determine whether or not the center point coordinate, the width and the height of each pattern match between the two image data D1 and D2 for the entire region of the reticle on the X and Y coordinates, for example. Accordingly, it is necessary to scan all coordinate points on the entire region of the reticle, and the comparison at the comparator part 66 is carried out at an extremely high speed.

When a defect exists in the reticle and this defect is extremely small and is caused by a defective etching or the like, the second detection signal which indicates that the two image data D1 and D2 do not match lasts only for an extremely short time during the scan. However, since the comparator part 66 carries out the comparison at the high speed, the scan frequency is extremely high. For this reason, there is a problem in that it is difficult to distinguish the second detection signal which lasts for the extremely short time due to the existence of the extremely small defect and a noise signal which is caused by a distortion in the signal waveform due to the high frequency.

If the detection sensitivity of the comparator part 66 is increased, the noise signal will simply be detected as the second detection signal, that is, the existence of a defect in the reticle. On the other hand, if the detection sensitivity of the comparator part 66 is decreased, it becomes impossible to detect an extremely small defect in the reticle. Generally, these problems always occur in the image data inspecting method and apparatus which inspect the matching state of the two

SUMMARY OF THE INVENTION

Accordingly, it is a general object of the present invention to provide a novel and useful image data inspecting method and apparatus in which the problems described above are eliminated.

Another and more specific object of the present invention is to provide an image data inspecting method for detecting whether or not a pattern described by a first image data and a pattern described by a second image data match, comprising the steps of (a) carrying out a sizing process on the first and second image data so that the patterns described thereby are at least enlarged or reduced by the same amount, and (b) comparing the first and second image data which are processed in the step (a) to determine whether or not the processed first and second image data match. According to the image data inspecting method of the present invention, it is possible to easily detect an extremely small difference between the two image data even when a high speed scan is made during the inspection, without the need to specially improve the sensitivity of a comparator part which makes the comparison.

Still another object of the present invention is to provide an image data inspecting apparatus for detecting whether or not a pattern described by a first image data and a pattern described by a second image data match, comprising processing means for carrying out a sizing process on the first and second image data which are read from the memory means so that the patterns described thereby are at least enlarged or reduced by the same amount, memory means, coupled to the processing means, for storing processed first and second image data which are processed in the processing means, comparator means, coupled to the memory means, for comparing the processed first and second image data which are read from the memory means to determine whether or not the processed first and second image data match, and output means, coupled to the comparator means, for outputting a result of the comparison in the comparator means. According to the image data inspecting apparatus of the present invention, it is possible to easily detect an extremely small difference between the two image data even when a high speed scan is made during the inspection, without the need to specially improve the sensitivity of the comparator means.

Other objects and further features of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a system block diagram for explaining an example of a conventional reticle image inspecting method;

FIG.2 is a system block diagram for explaining the operating principle of the present invention;

FIG.3 is a flow chart for explaining an embodiment of an image data inspecting method according to the present invention;

FIGS.4A through 4E are diagrams for explaining an enlargement process;

FIGS.5A and 5B are diagrams for explaining a reduction process;

FIG.6 is a system block diagram showing an embodiment of an image data inspecting apparatus according to the present invention; and

FIG.7 is a diagram showing an embodiment of a reading part shown in FIG.6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First, a description will be given of the operating principle of the present invention, by referring to FIG.2.

In the present invention, first and second image data D1 and D2 which respectively describe a pattern are compared to detect whether or not the patterns match. The first image data D1 is stored in a memory 1_1, and the second image data D2 is stored in a memory 1_2. An image data processing part 2_1 processes the first image data D1 so that all patterns described by the first image data D1 are enlarged or reduced by the same amount, and an image data processing part 2_2 processes the second image data D2 so that all patterns described by the second image data D2 are enlarged or reduced by the same amount. Hence, the first and second image data D1 and D2 are enlarged or reduced by the same amount and respectively formed into a first processed image data D1A and a second processed image data D2A. The above image data processing is also referred to as a sizing process. A comparator part 3 compares the first and second processed image data D1A and D2A so as to detect whether or not the two described images match. A comparison result output from the comparator part 3 is supplied to an output part 4.

According to the conventional method, the image data correcting parts 64 and 65 simply operate independently of each other depending on the modifications to be made of the image data. However, in the present invention, the operations of the two image data processing parts 2_1 and 2_2 prior to the image data comparison are controlled and linked so that the same image data processing is carried out with respect to the two image data D1 and D2. The two image data D1 and D2 are enlarged or reduced so as to facilitate the determination of whether or not the two image data D1 and D2 match. In other words, the image data processing carried out in each of the image data processing parts 2_1 and 2_2 is an enlargement or reduction

of the existing patterns. In this case, the conventional image data correcting part may be used as the image data processing part 2_1 or 2_2.

Because all patterns described by the two image data D1 and D2 are enlarged or reduced by the same amount, the difference between the two image data D1 and D2 is enlarged by the enlargement or reduction of the patterns. As a result, the second detection signal which is detected during the scan at the comparator part 3 lasts for a longer time when compared to the conventional method, and it is possible to detect that the two image data D1 and D2 do not match with more ease when compared to the conventional method.

Next, a description will be given of an embodiment of an image data inspecting method according to the present invention, by referring to FIG.3. In this embodiment, the present invention is applied to the inspection of the reticle.

In FIG.3, a step S2 converts patterns D11 drawn on a reticle 21 into an electrical signal by use of a photoelectric conversion means such as an optical device and a charge coupled device (CCD), so as to read the pattern image. This electrical signal forms a first image data D1. On the other hand, a step S2 converts the format of a test data D21 which is prepared for use in inspecting the reticle 21, so that the format of a second image data D2 has the same format as the first image data D1. A step S3 enlarges or reduces the image data D2, and a step S4 enlarges or reduces the image data D1. The image data processing at the steps S3 and S4 is controlled so that the enlargement or reduction is made for the same amount. The steps S3 and S4 may be carried out simultaneously by two independent image data processing means or carried out successively by a single image data processing means.

The "enlargement" process refers to the process of enlarging all of the patterns described by the image data by moving each pattern contour to the outside and enlarging each pattern. The amount of the enlargement need not be the same for each direction. On the X-Y coordinate system, for example, a pattern having a width W and a height H may be enlarged by enlarging only the width W in the X direction or enlarging the width W in only the positive X direction. The pattern may be enlarged by enlarging the width W and the height H by a certain ratio. Further, the pattern may be enlarged by enlarging the width W and/or the height H by a constant amount. When detecting an extremely small defect, it is effective to enlarge the width W by a fixed amount in the X direction which is the scan direction, for example.

The "reduction" process refers to the process of reducing all of the patterns described by the image data by moving each pattern contour to the inside and reducing each pattern. In other words, the reduction process is a reverse process of the enlargement process, and the amount of the reduction need not be the same for each direction, as in the case of the enlargement.

Next, a description will be given of the enlargement process which is carried out with respect to the image data, by referring to FIGS.4A through 4E.

In FIG.4A, the reticle image data (first image data) D1 includes data related to a pattern 101 and an extremely small defect 102. When this reticle image data D1 is enlarged by the same constant amount in all directions, a processed reticle image data D1A shown in FIG.4C is obtained. In the processed reticle image data D1A, the defect 102 is enlarged to a defect 112.

On the other hand, the test image data (second image data) D2 shown in FIG.4B is also subjected to the same enlargement process and formed into a processed test image data D2A shown in FIG.4D. The test image data D2 includes a pattern 201, and this pattern 201 is enlarged to a pattern 211 in the processed test image data D2A.

The two processed image data D1A and D2A are compared, and a compared output image data D3 shown in FIG.4E is obtained as a result of the comparison. This compared output image data D3 includes a defect 301 which corresponds to the defect 102 and is enlarged with respect to the defect 102. In other words, the defect 301 corresponds to the enlarged difference between the two image data D1 and D2. Accordingly, the extremely small defect 102 in the reticle image data D1, which may not be found according to the conventional method depending on the detection sensitivity, can positively be detected as the defect 301 according to this embodiment. Hence, the reticle can be inspected with a high reliability, and the defect of the reticle can be found with a high accuracy.

If the reticle image data D1 shown in FIG.4A were used to form a contact hole in a semiconductor device for interconnection purposes, for example, the pattern 101 is used as the contact hole. However, the existence of the defect 102 would form a contact hole where an interconnection should not be made. Hence, it may be seen that the elimination of the defect 102 is essential in such a case.

Next, a description will be given of the reduction process which is carried out with respect to the image data, by referring to FIGS.5A and 5B.

In FIG.5A, the reticle image data (first image data) D1 includes data related to a pattern 103 and an extremely small defect 104. When this reticle image data D1 is reduced by the same constant amount in all directions, a processed reticle image data D1A shown in FIG.5B is obtained. In the processed reticle image data D1A, the defect 104 is enlarged to a defect 114.

On the other hand, a test image data (second image data) D2 is also subjected to the same reduction process and formed into a processed test image data D2A. The test image data D2 includes a pattern

but no defect, and this pattern is reduced in the processed test image data D2A.

The two processed image data D1A and D2A are compared, and a compared output image data D3 is obtained as a result of the comparison. This compared output image data D3 includes a defect which corresponds to the defect 104 and is enlarged with respect to the defect 104. In other words, the defect in the compared output image data D3 corresponds to the enlarged difference between the two image data D1 and D2. Accordingly, the extremely small defect 104 in the reticle image data D1, which may not be found according to the conventional method depending on the detection sensitivity, can positively be detected as the defect 301 according to this embodiment. Hence, the reticle can be inspected with a high reliability, and the defect of the reticle can be found with a high accuracy.

The reduction process is particularly effective in finding a defect when the pattern exists over a large region and the defect signal which is related to the extremely small defect in the reticle corresponds to a signal which describes an image in which no pattern exists.

If the reticle image data D1 shown in FIG.5A were used to prevent formation of an impurity region when injecting impurities into layer of a semiconductor device, for example, the pattern 103 is used as the mask. However, the existence of the defect 104 would form an impurity region at a location where no impurity region should not be formed. Hence, it may be seen that the elimination of the defect 104 is essential in such a case.

Returning to the description of FIG.3, a step S5 compares the processed reticle image data D1A and the processed test image data D2A to determine whether or not the two image data match. A step S6 outputs the result of the comparison made in the step S6. For example, the result of the comparison is displayed on a display.

Next, a description will be given of an embodiment of an image data inspecting apparatus according to the present invention, by referring to FIG.6.

In FIG.6, a pattern D11 of a reticle 51 is read or scanned by an optical device (not shown) and a photoelectric conversion part 52, and a reticle image data which is read is stored in an image memory 53. On the other hand, a test image data D21 which is recorded on a magnetic tapė 54 is reproduced and supplied to a format converting part 55. The format converting part 55 converts the signal format of the test image data D21 to a signal format identical to that of the reticle image data which is stored in the image memory 53. The test image data having the converted signal format is stored in an image memory 56.

An enlarge/reduce processing part 57 carries out an enlarging process or a reducing process with respect to the image data which are stored in the image memories 53 and 56. A processed reticle image data which is obtained as a result of the image processing in the enlarge/reduce processing part 57 is stored in the image memory 53, while a processed test image data which is obtained as a result of the image processing in the enlarge/reduce processing part 57 is stored in the image memory 56. The processed reticle image data read from the image memory 53 and the processed test image data read from the image memory 56 are supplied to a comparator part 58 and compared therein. A result of the comparison in the comparator part 58 is supplied to an output part 59 and displayed, for example. The result of the comparison which is displayed is as shown in FIG.4E, for example, if the processed reticle image data and the processed test image data do not match.

The enlarging and reducing processes are further disclosed in a United States Patent No.4,809,341, for example. The enlarging and reducing processes are respectively referred to as "reduction" and "magnification" in this United States Patent.

FIG.7 shows an embodiment of a reading part shown in FIG.6. In FIG.7, the reticle 51 is placed on a stage 153 and is irradiated from the back side by a light emitted from a light source 154. The light from the light source 154 is transmitted through the reticle 51 with the aid of lens systems 155, and the transmitted light is received by a sensor 156 which corresponds to the photoelectric conversion part 152 shown in FIG.6. The stage 153 is moved by a stage drive mechanism 157 which may be controlled by a control unit (not shown) which controls the operation of the apparatus shown in FIG.6. Hence, the reticle 51 on the stage 153 can be moved in X and Y directions.

For example, the sensor 156 includes one dimensional charge coupled device (CCD) having 1024 detecting eleemnts linearly arrayed. In this embodiment, the sensor 156 scans a distance of 1 mm in the X direction and detects the reticle surface of 1 mm length along the Y direction. As a result, an area of 1 mm^2 on an object surface is resolved into 1024x1024 bit data and this data is stored in the image memory 53 shown in FIG.6.

In the above described case, 1 bit of the data represents whether or not the pattern exists in an area of about 1 μm^2. The object area represented by each bit of data varies depending on a magnifying ratio of the lens systems 155, and therefore, it is possible to inspect the reticle 51 by changing only the magnification ratio of the lens systems 155.

In the embodiments described above, the present invention is applied to the inspection of the reticle image. However, the present invention is applicable to any type of inspection which requires comparison of two image data to determine whether or not the two image data match. For example, the present invention is also applicable to the collating of a mask data with

chip and the like, and comparison of two identical chips. When comparing two identical chips, the image data of the two chip patterns which are obtained via the optical device and the photoelectric conversion device are stored in image memories, and after enlarging or reducing the two image data a comparator part compares the two processed image data to determine whether or not the two image data match. Hence, it is possible to inspect the sameness of the two chips with ease.

In addition, in the above described embodiments, each image data describes the reticle pattern using the same signal format. However, the image data does not necessarily have to use the same signal format. In other words, the image data related to the reticle normally describes the reticle pattern using a signal format such that the region of the reticle is divided into a plurality of small regions and the reticle pattern is described in terms of the small regions. In this case, the signal format of the reticle image data may or may not be converted into the signal format identical to that of the test image data, because the comparator part may be provided with a function of carrying out predetermined processes corresponding to the enlarging or reducing process on the two image data having mutually different signal formats when making the comparison.

In the described embodiments, the enlarging or reducing process is carried out once with respect to the two image data which are compared. However, in order to improve the accuracy with which the two image data are collated, it is possible to make one comparison after enlarging the two image data and to make another comparison after reducing the two image data, so as to ensure enlargement of the difference between the two compared image data if any.

Claims

1. An image data inspecting method for detecting whether or not a pattern described by a first image data (D1) and a pattern described by a second image data (D2) match, characterized in that said image data inspecting method comprises the steps of:

   (a) carrying out a sizing process on the first and second image data so that the patterns described thereby are at least enlarged or reduced by the same amount; and

   (b) comparing the first and second image data which are processed in said step (a) to determine whether or not the processed first and second image data (D1A, D2A) match.

2. The image data inspecting method as claimed in claim 1, characterized in that said step (b) compares the processed first and second image data (D1A, D2A) once when said step (a) carries out an enlarging process, and also compares the processed first and second image data (D1A, D2A) once when said step (a) carries out a reducing process.

3. The image data inspecting method as claimed in claim 1 or 2, characterized in that said first image data (D1) is related to an actual pattern and said second image data (D2) is related to a test pattern.

4. The image data inspecting method as claimed in claim 3, characterized in that said first image data (D1) is related to the actual pattern of an element selected from a group consisting of a reticle, a mask, a wafer and a semiconductor chip.

5. The image data inspecting method as claimed in any of claims 1 to 4, characterized in that there is provided the step (c) of obtaining the first image data (D1) by optically scanning the pattern which is described thereby.

6. The image data inspecting method as claimed in any of claims 1 to 5, characterized in that there is further provided the step (c) of converting a signal format of one of the first and second image data (D1, D2) so that the first and second image data have the same signal format when compared in said step (b).

7. The image data inspecting method as claimed in any of claims 1 to 6, characterized in that there is further provided the step (c) of displaying a result of the comparison in said step (b).

8. An image data inspecting apparatus for detecting whether or not a pattern described by a first image data (D1) and a pattern described by a second image data (D2) match, characterized in that said image data inspecting apparatus comprises: processing means (57) for carrying out a sizing process on the first and second image data so that the patterns described thereby are at least enlarged or reduced by the same amount; memory means (53, 56), coupled to said processing means, for storing processed first and second image data (D1A, D2A) which are processed in said processing means; comparator means (58), coupled to said memory means, for comparing the processed first and second image data which are read from said memory means to determine whether or not the processed first and second image data match; and output means (59), coupled to said comparator means, for outputting a result of the comparison in said comparator means.

9. The image data inspecting apparatus as claimed in claim 8, characterized in that said comparator means (58) compares the processed first and second image data (D1A, D2A) once when said processing means (57) carries out an enlarging process, and also compares the processed first and second image data (D1A, D2A) once when said processing means (57) carries out a reducing process.

10. The image data inspecting apparatus as claimed in claim 8 or 9, characterized in that said first image data (D1) is related to an actual pattern and said second image data (D2) is related to a test pattern, said first and second image data being initially stored in said memory means (53, 56).

11. The image data inspecting apparatus as claimed in claim 10, characterized in that said first image data (D1) is related to the actual pattern of an element selected from a group consisting of a reticle, a mask, a wafer and a semiconductor chip.

12. The image data inspecting apparatus as claimed in any of claims 8 to 11, characterized in that there is further provided reading means (52, 153-157) for obtaining the first image data (D1) by optically scanning the pattern which is described thereby.

13. The image data inspecting apparatus as claimed in any of claims 8 to 12, characterized in that there is further provided converting means (55), coupled to said memory means (56), for converting a signal format of one (D2) of the first and second image data so that the first and second image data (D1, D2) have the same signal format when compared in said comparator means (58).

14. The image data inspecting apparatus as claimed in any of claims 8 to 13, characterized in that said output means (59) displays the result of the comparison made in said comparator means (58).

FIG.1 PRIOR ART

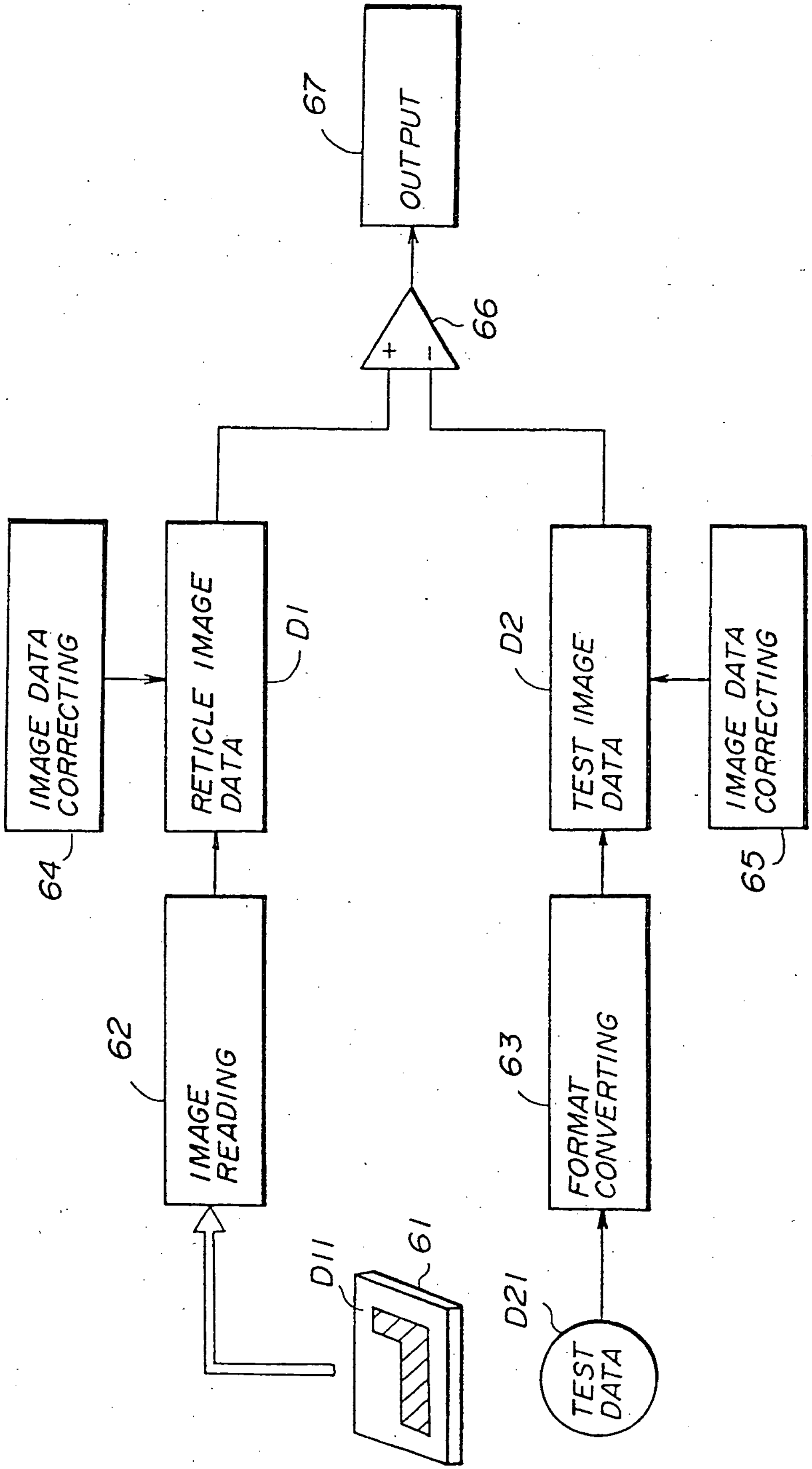


FIG.2

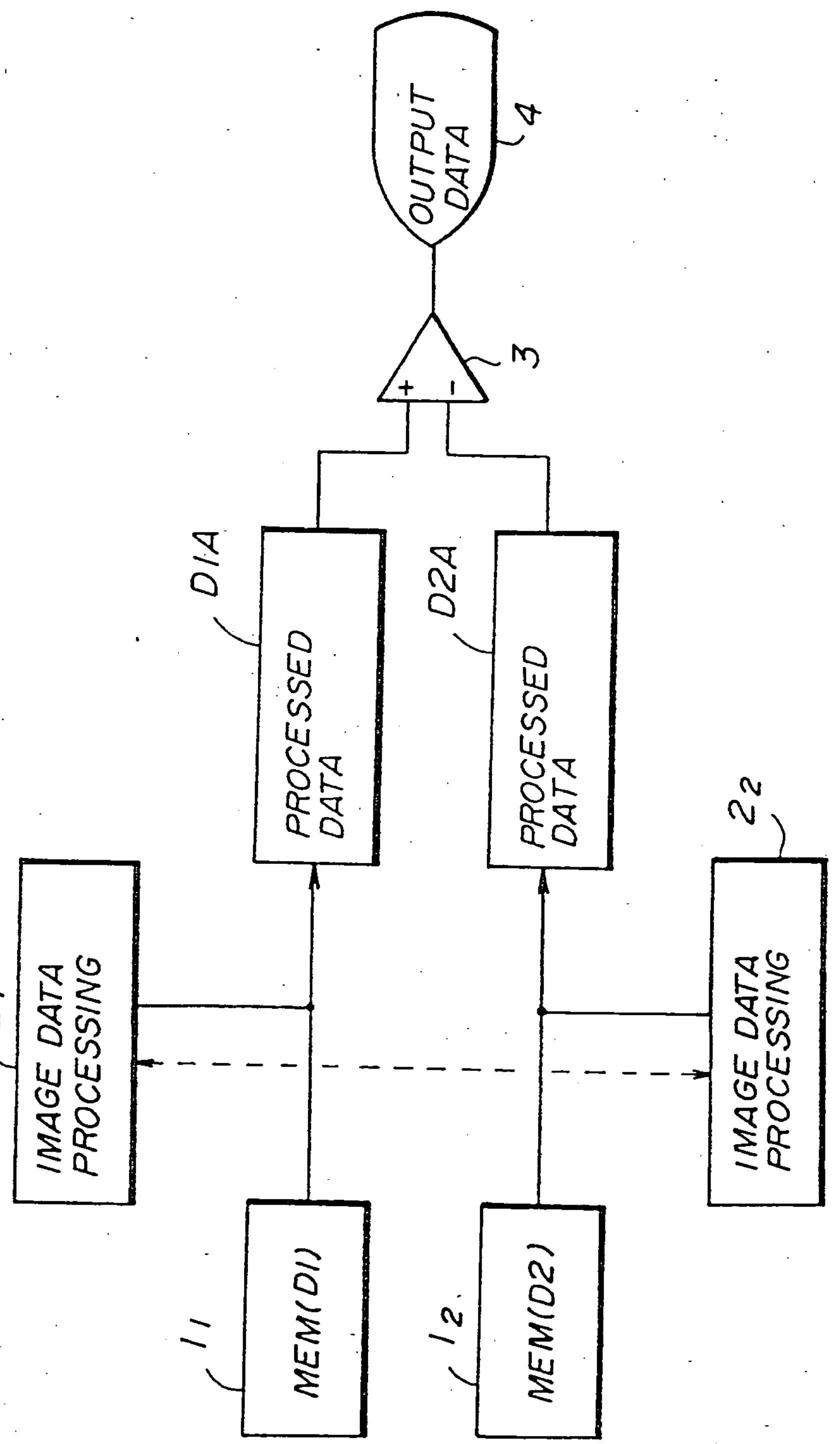

OUTPUT DATA
4
3
+
-
D1A
PROCESSED DATA
D2A
PROCESSED DATA
2₂
IMAGE DATA PROCESSING
2₁
IMAGE DATA PROCESSING
1₁
MEM(D1)
1₂
MEM(D2)

FIG. 3

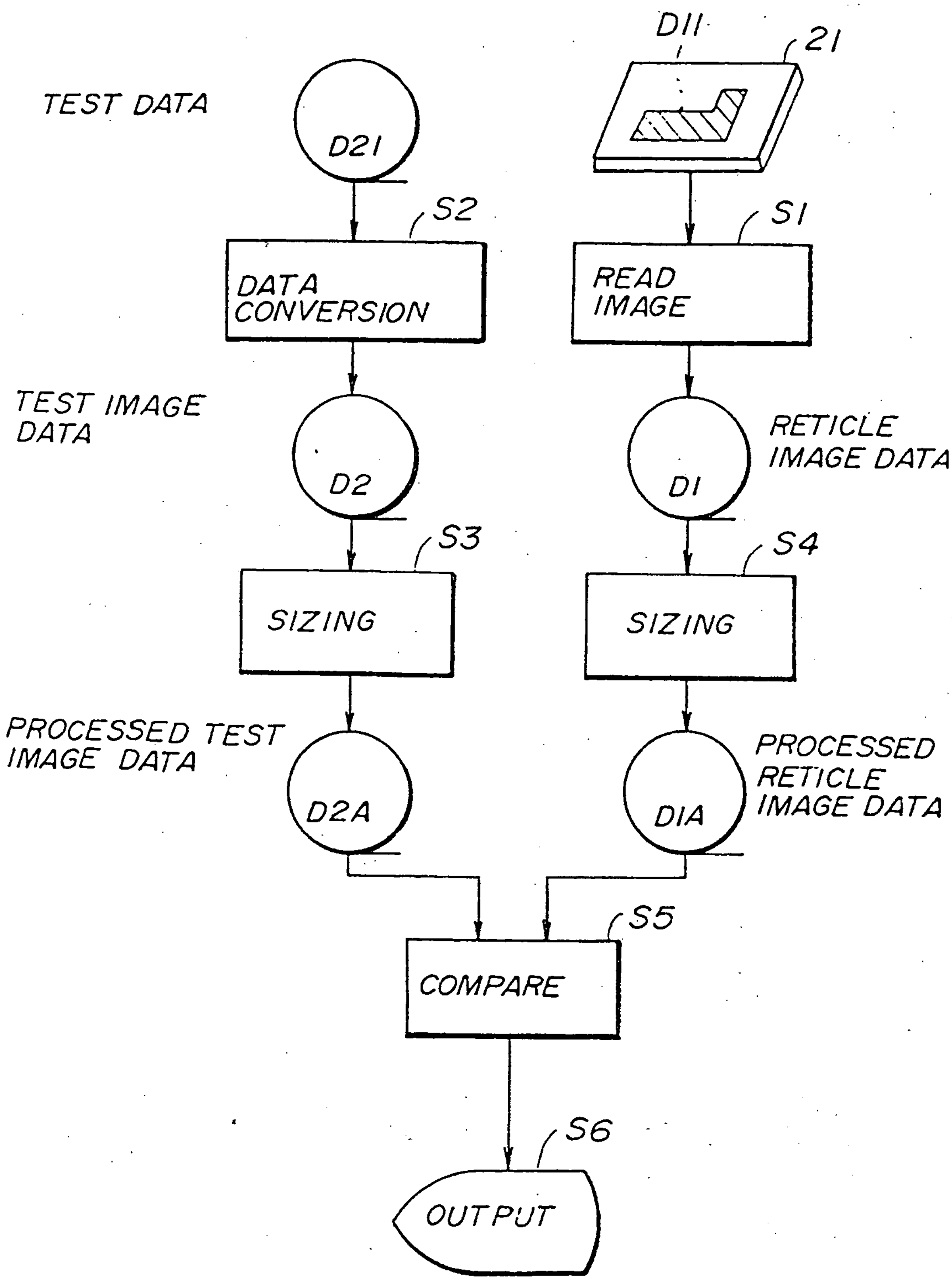

TEST DATA
D21
D11
21
S2
DATA CONVERSION
S1
READ IMAGE
TEST IMAGE DATA
D2
RETICLE IMAGE DATA
D1
S3
SIZING
S4
SIZING
PROCESSED TEST IMAGE DATA
D2A
PROCESSED RETICLE IMAGE DATA
D1A
S5
COMPARE
S6
OUTPUT

FIG.4B

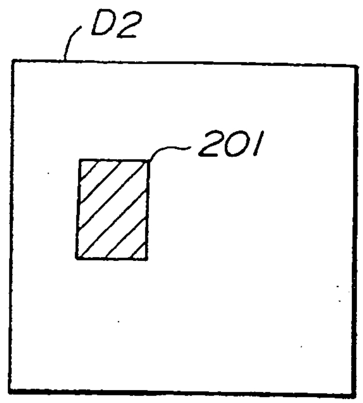


FIG.4A

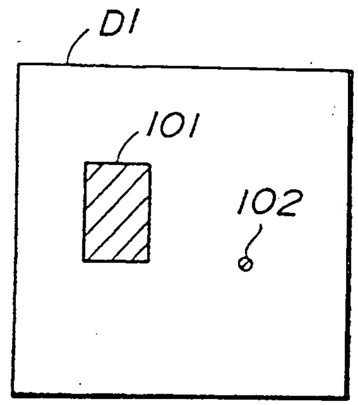


FIG.4D

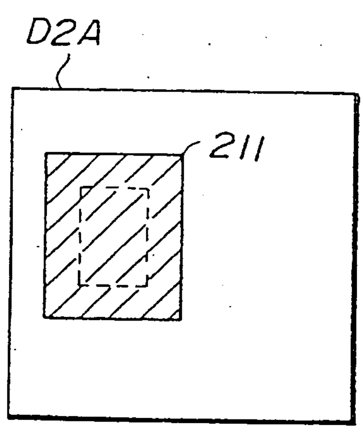


FIG.4C

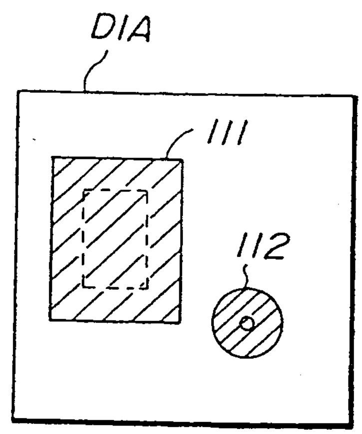


FIG.4E

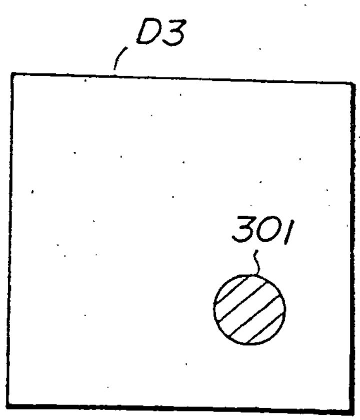


FIG.5A

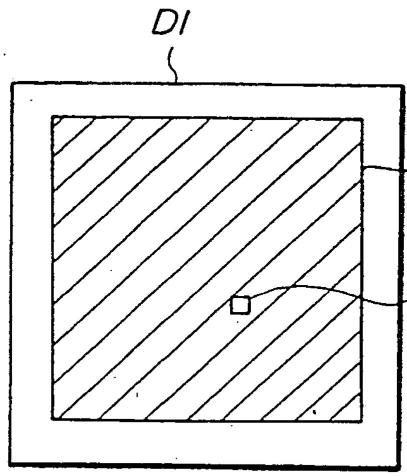


FIG.5B

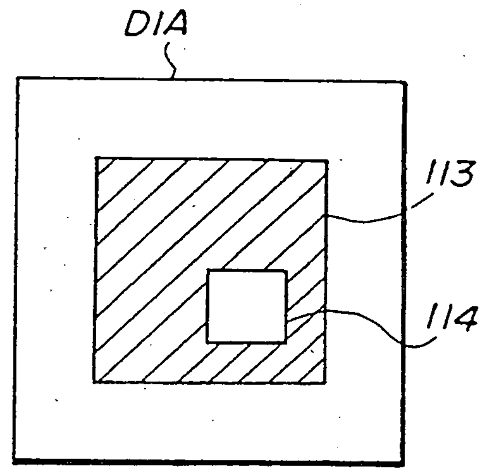


FIG.7

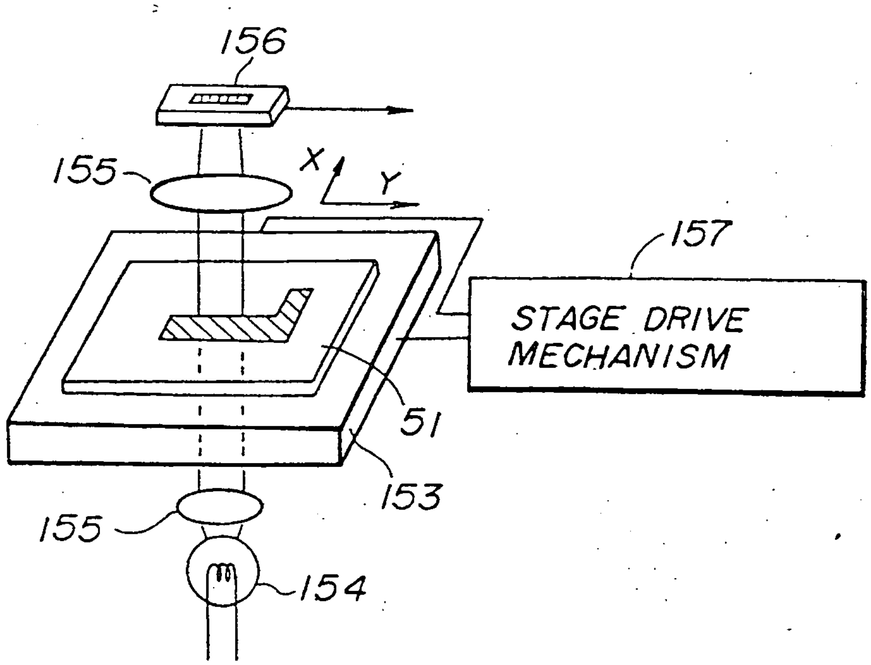
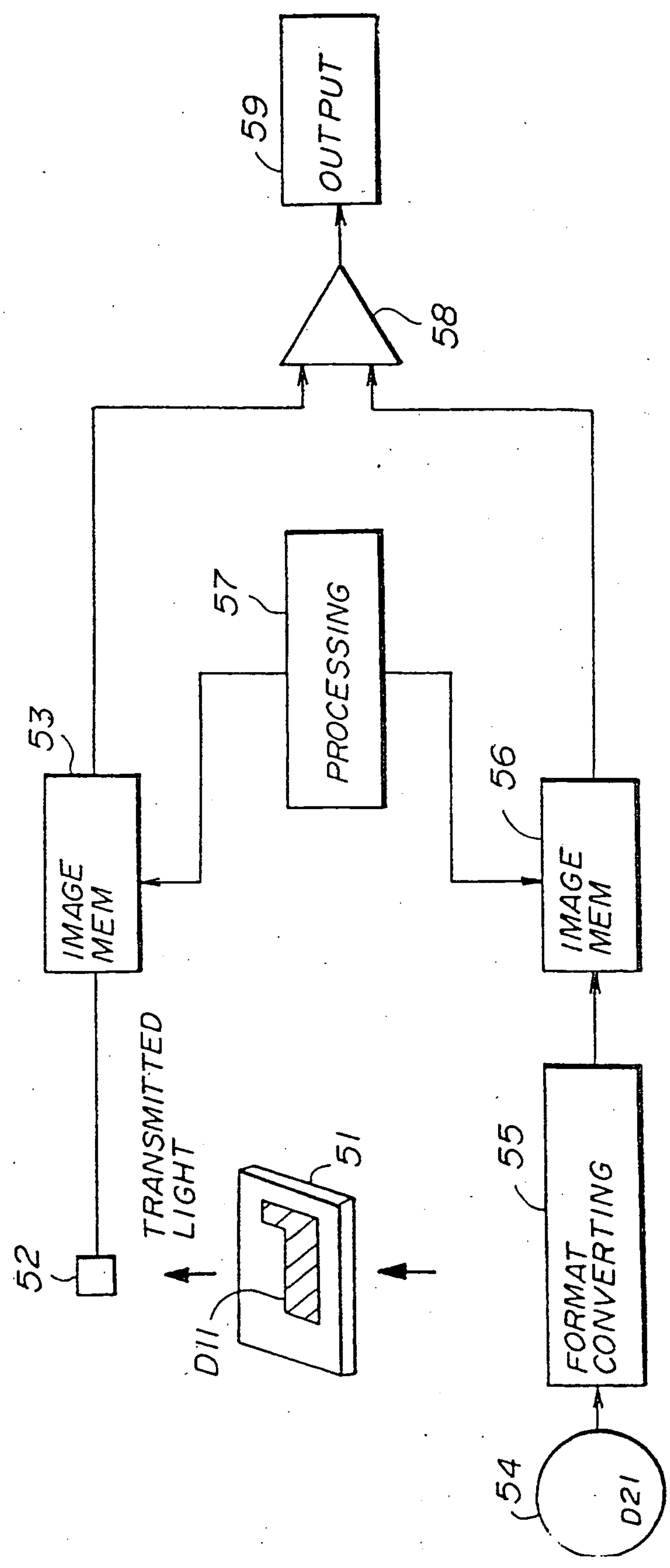


FIG.6


52
TRANSMITTED LIGHT
51
D11
53
IMAGE MEM
57
PROCESSING
56
IMAGE MEM
55
FORMAT CONVERTING
54
D21
58
59
OUTPUT